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November 5, 1984

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HOW MATERIALS USE IS CHANGING UNDER THE HOOD

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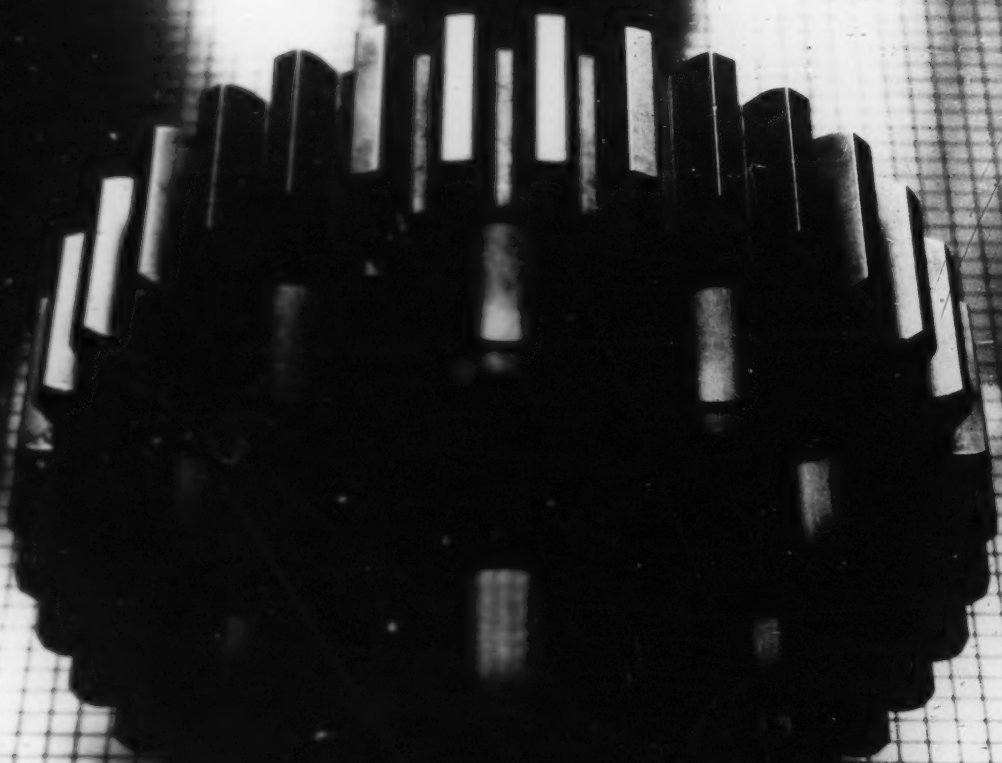

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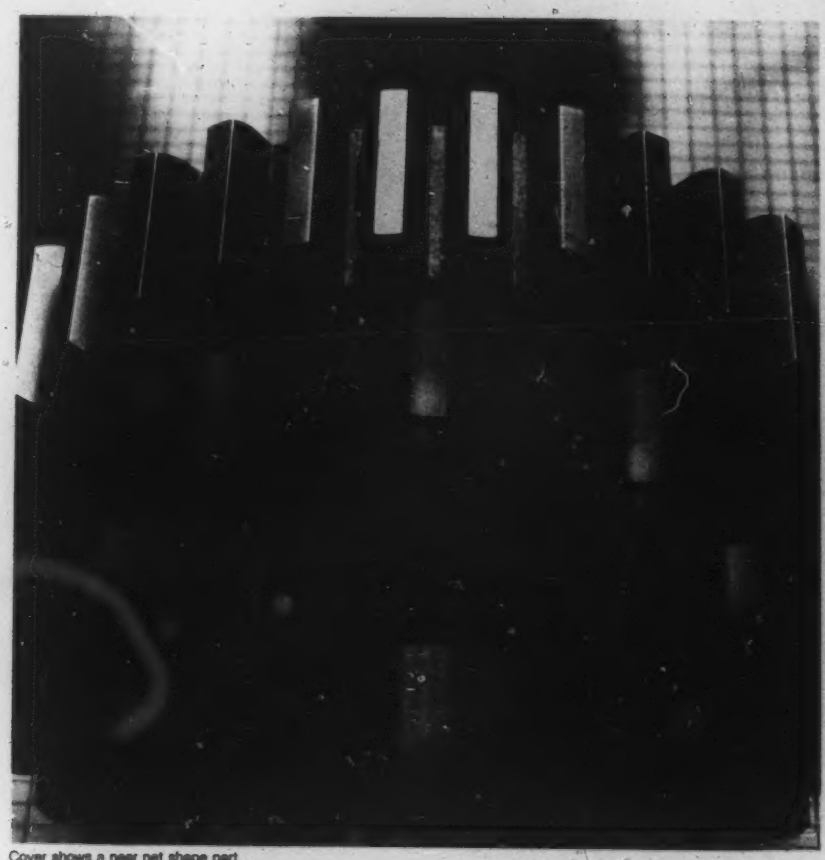

Cover shows a near net shape part.

Editorial 5
Just what are we buying overseas?

Newswatch 11
How aluminum producers stack up in the can body market.

Metalcutting Fluids: Solutions Finding A Problem 18
In an uneven recovery, it seems like the busiest man on the block is the metalcutting fluids specialist.

Near Net Shapes 31
Producing final parts that require little or no machining characterizes near net shapes, which provide a good example of the term 'cost-effectiveness.'

Auto Materials 50
The future looks promising for non-metallic materials such as composites, ceramics and plastics for critical engine parts.

Materials Report 59
Steelmakers are still looking for the fourth quarter surge.

Next Issue: The Software Explosion in Manufacturing.

Departments

EDITORIAL STAFF	8
P&P DATA 10/22	60
FERROUS SCRAP 10/22	61
AD INDEX	62
MANAGEMENT SERVICE CARD	63
BUSINESS STAFF	64
STEEL PRICES	67
STEEL PRICES	68
CLEARING HOUSE	69

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Materials use is changing in many ways in the critical engine parts. Composites, ceramics and plastics are leading the charge.

The future is bright, though still uncertain, for non-metallic materials under the hood. Ceramic and plastic composite materials, already used for a number of parts today, could be the automakers' material of choice for more future structural components.

The great attraction of ceramics is their ability to withstand high temperatures: 2500° F so far, though ceramists hope to stretch that even higher, with fast-spinning wheels, or rotors, used to power turbochargers and gas turbine engines.

The heat generated by the explosion in the internal-combustion engine goes three ways: Some provides power, propelling the pistons; some is released as exhaust; and some is cooled by the coolant. The latter two processes are parasitic, dissipating the heat rather than using it for the transmission of car-moving power.

Turbochargers harness the energy from the exhaust gases to spin a turbine wheel, which turns an air pump (see related drawing p. 54). The pump compresses the air and forces it back into the engine. This force-fed air increases the explosion and resulting horsepower, since the gas-piston engine burns up all the air available in the combustion chamber. Diesels use about twice as much air as gasoline engines, so turbochargers work particularly well with them.

As engineers add turbochargers to engine after engine in the U.S., Japan, and Europe, some are using ceramics to build the popular powerboosters. Mitsubishi uses a ceramic turbine wheel for its turbocharger wheel; Buick plans one for the 1986 model year; and Ford is considering one. Warner-ishi soon will produce a turbocharger in which not only the wheel but also the housing and bearing will be made of ceramic.

Garrett, the No. 1 maker of turbochargers, plans to introduce in the next two or three years the T2 turbocharger, which uses a ceramic turbine wheel. The T2 has been tested in the Nissan Pulsar NX and Pontiac Sunbird. The Sunbird's responsiveness was "significantly better than with a metal turbine metal," a Garrett spokesman said.

Like the turbocharger, the gas turbine engine uses a turbine wheel, which shoots air through a nozzle to a compressor. But the gas turbine engine's wheel is bigger and does the work of the piston in today's conventional engines: It directly drives the transmission. The power flows continuously in the gas-turbine engine, which is smoother than the intermittent-flow piston engine.

Unlike gas-piston engines, turbine engines burn up only about 20 pct of the oxygen in the combustion chamber. That significantly reduces the polluting emissions of carbon monoxide (CO) and hydrocarbons (HC). The turbine engine's spare oxygen (O) combines with the CO to form CO2 (carbon dioxide); and with the HC to form H2O (water) and CO2 (carbon dioxide), said Albert H. Bell, III, the executive engineer at the GM Tech Center's advanced product engineering staff.

The gas turbine engine can use a variety of fuels. Its efficiency has remained the same, said William G. Agnew of GM Research, when using methanol and a number of experimental fuels derived from petroleum, coal, oil shale, and tar sands. GM even demonstrated a turbine engine fueled by powdered coal.

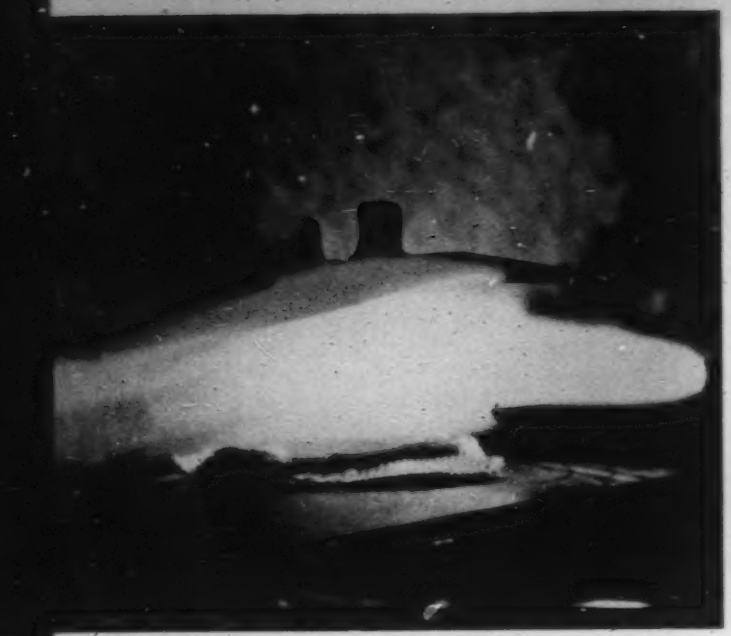
The turbine engine's problem, however, is its fuel economy. That can be raised by raising the engine temperatures, which requires materials that can withstand great heat: a job, in short, for ceramics.

"Right now our gas turbines have a fuel economy that's equal to conventional engines," said GM's Mr. Bell. "But that's not good enough. How widely turbine engines are used depends on how high we can raise temperatures and fuel economy."

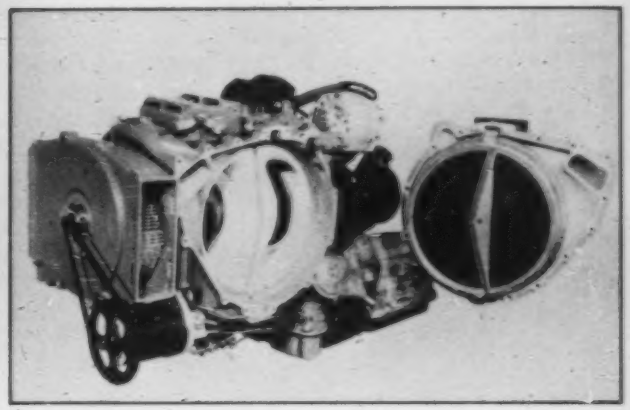
Ceramic gas turbines can reach 2500° and operate at 50-pct thermal efficiency, said John L. Mason, engineering vice president at Garrett, compared with 2000° and 35 to 40 pct for an uncooled metallic one. Thermal efficiency measures the critical ratio of power output to heat input.

At the Tokyo Auto Show last year, Nissan showed a gas-turbine engine the company plans to produce. The en-

BY BRYAN H. BERRY



Ceramics can withstand temperatures of up to 2600°F but are brittle. Here an experimental ceramic component of a Garrett turbine is tested in a furnace flame. Also pictured is an experimental gas-turbine engine design of GM's AGT-5.



gine's turbine wheel, burner, and some other parts were made of ceramic.

Gas Turbine Projects

Building a ceramic turbine engine that delivers good fuel economy is the goal of two advanced gas turbine (AGT) projects: The AGT100 and AGT101. Sponsored by the Dept. of Energy (DOE) and monitored by NASA, GM's Allison Gas Turbine Div. is working on the AGT100 while Ford and the Garrett Turbine Engine Co. work on the AGT101. The Allison engineers are developing a two-shaft turbine; Ford and Garrett, a one-shaft turbine.

"We still don't feel comfortable with our present ceramic rotor," Edwin E. Strain, the AGT101 program manager, told *Iron Age* last month. "By next year, however, we think we'll have a good ceramic rotor." The present ceramic rotor has gone 115,000 rpm in separate spin-tests, but one blade flew off the test engine at 97,000 rpm.

Ceramics' chief drawback is their brittleness. "Ceramics would be the most brittle of any material we've used in our engines," said William G. Hammer, a staff engineer at GM's Detroit Diesel Allison Div., which is testing ceramics for different engine parts.

Iron is more forgiving, gradually fatiguing as temperature or stress rises. Ceramics maintain the same high strength up to much higher temperatures but then suddenly break. "They fail catastrophically," say technicians to describe this sudden fracturing.

Sharp edges and corners and sharply angled twists are most prone to cracking on ceramic parts. Those are the kinds of shapes designers try to avoid.

"We've thickened the blades to reduce stresses," said Mr. Strain. "We've minimized stresses at holes and corners. Every ceramic part in the AGT101, except for one housing, is symmetrical." The AGT101 has 60 ceramic components, including 11 major structural parts.

Making Ceramic Parts

Ceramics are made by baking or firing nonmetallic, inorganic powders. They can be used as insulators or as structural components. Ceramics have been used for thousands of years for pottery and, more recently, for products such as spark plugs, toilets, and bathtubs. Their hardness makes them useful as industrial cutting tools.

Ceramics can reduce industry's need for the imported rare metals presently used for the nickel-based superalloy turbines. That's one big reason that the Japanese and the U.S. Dept. of Energy are so interested in ceramics.

Silicon carbide, silicon nitride, and zirconia are the three types of ceramics most widely being tested for use under the hood. "Those materials are still not well known," said Mr. Bell. "Their engineering characteristics have not been described well enough for us to be able to use them with confidence."

"Ceramics are where metals were fifty years ago," said Mr. Strain. "It will take a lot of work to get them ready for use in the engine."

Ceramic powders are pressed or molded to near net shape, so manufacturing them also is potentially less expensive than for metal parts. Some metal-casting operations have notoriously high scrap rates—up to 40 pct—because of problems with porosity.

Ceramics fabrication, however, is slow. And any additional machining that's required must be done in very slow passes with diamond tooling.

The AGT101 team has reduced the manufacturing time for structural ceramics from six to three weeks. "To mass-produce structural ceramics," said Mr. Strain, "the automakers would need a lot of furnaces, which would require large capital investments."

Making ceramics is like making powdered metals, though the sintering temperatures required for ceramics are higher. Silicon nitrides (Si_3N_4) can be formed either by sintering or by reaction bonding.

The sintering process is faster but requires 1 to 10 pct of additives. Unfortunately, these additives cause a part to creep at temperatures above 1800° F. Also, shrinkage of 12 to 17 pct during sintering makes it hard to maintain tolerances, said William D. (Dave) Carruthers, a materials engineering specialist in the AGT101 project.

Reaction-bonded silicon nitride (RBSN) uses few or no additives and so undergoes no shrinkage. But the silicon metal particles must be exposed to nitride for a nitriding cycle of 12 to 21 days. In the carefully controlled reaction, silicon nitride is formed.

The reaction-bonded silicon nitride can withstand higher temperatures than the sintered equivalent (see related table p. 51), because the RBSN uses fewer additives. However, the RBSN has a porosity of 15 pct, so it's not as strong as the sintered silicon nitride, which has only 2 or 3 pct porosity.

As engineers add turbochargers to engine after engine in the U.S., Japan and Europe some are using ceramics to build the popular power boosters.

"A small void or defect will cause a ceramic part to fail," said Mr. Hammer of Detroit Diesel Allison (DDA). "That's not true with metal.

"Ceramics makers need to learn to make consistently good parts. We want to see no defects larger than .002 in."

Zirconia expands at about the same rate as steel and is smoother than silicon nitride. Both characteristics make it a good insulator or liner that can be used with steel.

Silicon nitride, however, expands about one-quarter as much as steel. That presents problems when the two materials abut.

Some of the most active work on ceramics is taking place in Japan, whose government is supporting the development. Isuzu already is using a diesel-engine ceramic precombustion chamber that was developed jointly with Kyocera.

The AGT101 team is testing at 2500° a turbine shroud made from Kyocera's silicon carbide, NGK's sintered silicon nitride, Garrett's RBSN, and Carborundum's Alpha silicon carbide.

At the same temperature, AGT101 is testing the Carborundum product for the combustor baffle and stator. Ford Research and Garrett also have made RBSN stators. The AGT101 also is testing a ceramic-matrix rotary regenerator made by Corning Glass and NGK.

Detroit Diesel Allison is looking at ceramics for a variety of parts: Piston rings, valve trains, cam rollers, and precombustion chambers could be made of structural ceramics; pistons and piston domes of ceramic coatings. Mr. Hammer hopes that ceramics might eliminate the need for bushings for such parts as rollers.

When DDA first tested a zirconia piston ring, it cracked. The cause of such failures is twofold, said Mr. Hammer: The ceramics makers often have never made the automotive part, and automotive engineers have never designed the part for ceramics. A recipe for failure in using any new material is to design it exactly the way the old metal part was.

No Cooling System

Both Detroit Diesel Allison and Cummins are investigating ways to eliminate cooling systems in their big truck and off-highway diesel engines. Water in the cooling system can leak or boil off as steam. The oil then gets too hot, and the hoses and fan belt can break.

To eliminate the need for the cooling system, Cummins is using structural ceramics to design an adiabatic engine that would retain all its heat.

"We prefer the term 'low-heat-rejection' diesel," said Chuck Amann, head of GM Research's engine department. " 'Adiabatic' implies no heat loss from the cylinder gas, and that requires a cylinder material having zero thermal conductivity. We haven't found that material, yet, not even among the ceramics."

The U.S. Army also wants to eliminate the high-maintenance cooling system and to improve fuel economy. It's given DDA $250,000 to find out how to do that on the 6.2-liter engine used in the Army's Blazer cargo carrier.

Where will you see ceramics under the hood? They're already there in spark plugs and oxygen sensors, and you'll see more ceramic insulators and structural parts. Turbochargers already use ceramics for rotors and will use more soon for other parts as well. Manufacturers are hard at work on ceramic insulators for low-heat-rejection diesel engines.

And the gas turbine engine? "That might come a long way in the next ten years," said GM's Mr. Bell, "or it might go nowhere. People have predicted it was just over the horizon for the last forty years." Chrysler, in fact, equipped several cars with gas-turbine

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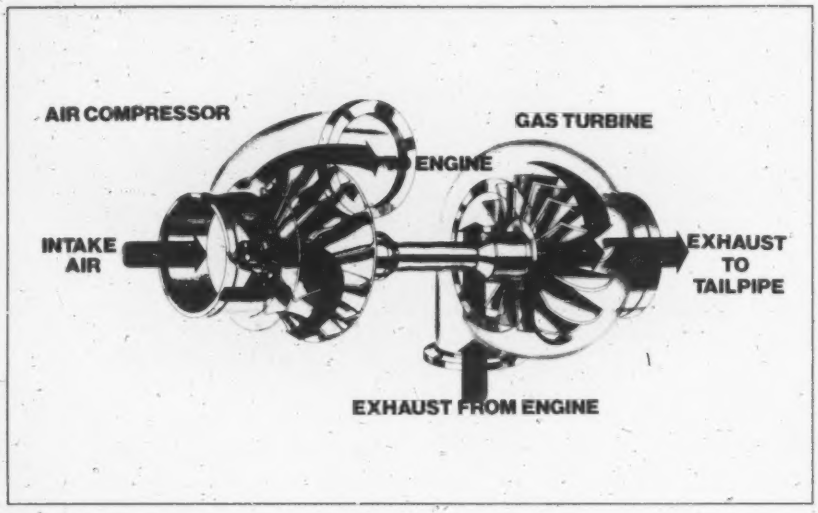
Ceramics are being used to make the wheels of turbochargers. In this drawing exhaust from the engine (red arrow at bottom) spins the turbocharger wheel and exits at right as exhaust through the tailpipe. Intake air (blue arrow at left) is sucked in through the air cleaner and blown (top blue arrow) to give more air and power to the engine.



engines in 1964.

The consensus: Gas-turbine engines won't be widely used for at least the next fifteen years—and maybe more. But if ceramics enable the AGT101 to meet its goal of 70 miles per gallon, look out; Ceramics gas-turbine engines could be on their way. On the other hand, the AGT101 program so far is funded only until 1986. It needs to get very near its goal in the next two years.

"If ceramics ever are developed well enough to be used in mass-volume engines," said GM's Mr. Bell, "then we want to be ready with the properly sized powerplant."

Plastic Composites

As chemists mix more blends that can withstand the 300° F temperatures under the hood, plastic composites are getting nearer and nearer the engine. DuPont's Minlon formula, for example, has a melting point of 495° F and is used to fabricate valve covers.

Cadillac and American Motors have used plastic-composite oil pans and rocker-arm covers. American Motors also uses a valve cover made of Nylon 66.

Nylon 6 and Nylon 66, a heat-stabilized mineral glass, are the only two composites most widely used under the hood. DuPont, Monsanto, and Celanese supply the latter; Allied, the former.

Radiator tanks and fans, heater housings, emission-control canisters, gears for oil and water pumps, transmission rotors and many other smaller parts are made of plastic composites throughout the auto industry.

Elsewhere in the car, the Corvette's front and rear leaf springs are plastic, and GM's small M van, soon to be released, looks likely to follow suit. And the success of the Pontiac Fiero, whose outer body panels are plastic, will spawn similarly constructed cars soon.

"We're going to see more plastic body panels from GM and the other companies," confidently predicted Irvin E. Poston, manager of the composites applications group of the GM Tech Center's manufacturing engineering staff. "The great majority of our work is on improving the productivity and quality of those kinds of parts and also moldings. But the area under the hood is also worth exploring."

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How Dupont sees plastics from bumper to bumper.

The great attraction of composites is that they can consolidate into one piece several metal ones. That eliminates the fasteners and gaskets required to tie the metal pieces together. Plastics, of course, also are lighter in weight and don't rust—though they can degrade.

The nylon oil-filter housing made by DuPont (see photo), for example, incorporates an integral intake tube right into the part. The valve cover made of DuPont's Minlon has a built-in drip rail. Nylon oil pans can replace two metal stampings that must be welded together.

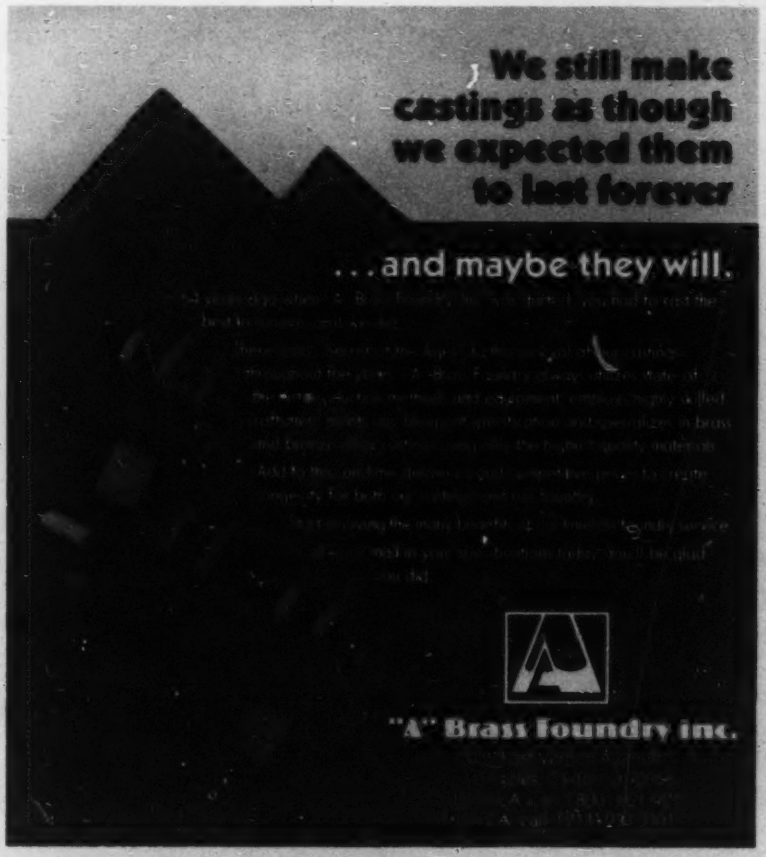
"It's pretty hard for plastics to beat out a regular metal stamping," pointed out Frank O. Swanson, an engineer in the plastics, sealants, and adhesives group of Ford's engine engineering office. "But once that stamping requires other operations, like welding or fastening on baffles or tubes, then plastics can be cost effective."

Composites lend themselves to more complex configurations than do metal stampings. Cadillac used a plastic torque chain cover because "it would have been difficult to make a conventional one-piece stamping in that shape," said Mr. Poston. As a bonus, the plastic part also weighed 40 pct less than the metal would have.

"Cadillac's plastic part is thicker than the metal one," said Mr. Poston. "But the composite's material density is one-quarter that of steel, so the plastic part can be two or three times as thick as the steel one and still save 40 pct of the weight.

"The modulus of composites is around 2 million, compared with steel's 30 million. So plastics must be thicker in order to pick up the required stiffness."

Plastic molding, on the other hand, "can always beat out metal castings in cost," said Ford's Mr. Swanson. "The material cost of plastic might be twice that of aluminum, for example, but an aluminum casting has to be thicker.



For Information, Circle 132

Glass Fiber Thermoset Composites in Cars

(Thousands of Pounds)

	1982	1983	1984	1985	1986	1987	1988
Body Panels	66407	100337	141763	150315	171348	174330	170592
Electrical	117	170	200	193	217	222	217
Passenger Compartment	3140	3784	5293	5898	6819	6817	8352
Suspension, Chassis, & Frame	420	1324	2059	2581	3584	3600	4361
Underhood	21212	26551	27897	23093	23141	23366	22711
Total Car	**91296**	**132166**	**177212**	**182080**	**205109**	**208335**	**206233**

In Trucks

	1982	1983	1984	1985	1986	1987	1988
Cab Interiors	21648	23754	25786	23047	22182	22060	22568
Cab Shell & Exteriors	20647	26311	30958	37697	37328	39454	40125
Engine Drive	1046	1152	1315	1355	1315	1378	1355
Exterior Accessories	3531	3786	3866	4043	3898	3898	3911
Suspension, Chassis, & Frame	894	1012	1622	2948	5266	11376	11515
Tilt Front Ends	7691	10845	13080	14378	14270	14270	14478
Underhood	7174	7565	7690	7466	7246	7246	7306
Total Truck	**62631**	**74425**	**34316**	**90934**	**91505**	**99682**	**101258**

Source: Owens-Corning Fiberglas Corp., Nov. 1983

Plus, plastic moldings don't have the problem with porosity that metal castings do."

For the past three years, Ford has been using the lost-wax method of molding plastic parts that have interior cavities: manifolds and water pumps, for example. An alternative is to weld two or more thermoplastic parts by ultrasonics, vibration, or heat. Thermosets can't be ultrasonically welded, said Mr. Swanson, so lost-wax molding is particularly useful for them.

Thermoplastics range from polyethylene and polypropylene, which cost less than 50¢ per lb to polyamides like Nylon ($1.50 per lb), polyamides (over $2 per lb), and Polyimides ($6-8 per lb). The greater the thermoplastic's ability to withstand heat, the more expensive it is.

Thermosets include polyesters (under $1 per lb) and epoxies (over $1 per lb).

Manufacturing cycling times range from one to two minutes for thermoplastics and from two to four minutes for thermosets. Cycle times are gradually decreasing, said Mr. Poston, who fore-

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TOUGH QUESTION

sees 45 seconds for thermoplastics and one minute for thermosets in the next ten years or so. That will improve composites' competitive position against metals.

Industry technicians presently are working on transfer molding, which combines elements of compression and injection molding. "A larger slug of material is transferred from a cylinder through a relatively larger opening into the mold cavity," said Mr. Poston. In conventional injection molding, the material is forced through a small gate.

The normal operating temperature in most parts under the hood is around 250°F, though the hottest parts can climb above 300°F. Polyethylene and polypropylene can't stand 200°F. Some of the high-performance plastics can go through 350°F paint ovens, and some new, expensive ($3-6 per lb) plastics like PPS and PEEK can withstand 450°F. Plastics are organic, and organic materials can't live at temperatures above 800°F.

Plastics expand two or three times more than metals do—a characteristic that must be considered in designing plastic parts.

Unfortunately, pointed out Mr. Swanson, "design engineers rarely design parts that take plastics' characteristics into account. Nine times out of ten, the first generation of plastic parts look just like the metal parts and are put on the vehicles the same way the metal parts are—even using screws when plastic can be attached more efficiently. The engineers haven't really convinced themselves that plastic will do the job."

Besides lacking experience with many of the new plastics, engineers must figure out all the different plastic-classification codes used by the different car companies. The American Society for Testing and Materials (ASTM) has developed a common code for plastics that Mr. Swanson hopes will be used throughout industry and government in the next five years.

Plastics can catch fire, and engineers need to design against that. They're still frightened by the memory of the 1970 Pinto whose plastic air cleaner caught on fire: Backfiring ignited gasoline in the cleaner tray.

"Under 99.9 pct of operating conditions, plastics have no problem with fire," said Mr. Poston. "The problem is that 0.1 pct where excessive heat can create conditions for a fire. We just need to design against that."

Rubber and graphite are two other materials winning new parts under the hood. Starting with some 1985 models, Ford plans to introduce all-rubber gaskets for the oil pans and rocker-arm covers, eventually on all models.

Ford's timing belts are silicone rubber reinforced with two plies of DuPont's Nomax composite. Rubber can withstand 500°F, said Edward J. Duda, an engineer in the materials, fasteners, and value engineering section of Ford's engine engineering group.

Graphite is used to make the gasket with which Ford mounts its exhaust-gas recirculation (EGR) system directly on the engine.

In a major effort to eliminate engine leaks, Ford has authorized its engineers to spend $10 more per engine on better gaskets and seals. That should mean another wave of nonmetallic parts under the hood. □

LAWNMOWERS BY FRIDAY?

SIMPLE ANSWER

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PRICE & PRODUCTION DATA

(Effective October 22, 1984)

Steel production by districts, thousands of tons (000 omitted)

	Last Week	Two Weeks Ago	Month Ago	Year Ago
North East Coast	123	129	124	183
Pittsburgh	198	191	230	229
Youngstown	95	98	99	113
Lake Erie	137	140	159	142
Detroit	139	133	116	134
Chicago	351	360	350	493
Cincinnati	86	84	81	105
St. Louis	75	78	74	79
Southern	166	156	159	147
Western	77	69	70	99
U.S. Production	1,447	1,438	1,462	1,733

Source: American Iron & Steel Institute

Lake Superior Ore Prices

51.50% Fe Natural delivered lower Lake ports. Rail transportation, handling and unloading may be charged to the account of the buyer. Coarse ore 80¢ premium.

Pellets (per iron unit natural).....gross-ton 80.50-86.9*
Mesabi, regular-unscreened.....gross-ton $32.53
Mesabi, non-bessemer.....gross-ton $30.03-31.53**

*80.50¢—Pickands Mather as of 1/27/81.
86.9¢—U. S. Steel as of 3/15/82. Cleveland-Cliffs as of 2/26/82, Oglebay Norton as of 3/25/82, and Hanna Mining as of 2/26/82.
**Effective 8/1/83.

STEEL PRODUCTION, COMPOSITE PRICES

(Effective October 22, 1984)

U.S. Steel Production	Last Week	Two Weeks Ago	To Date 1984	To Date 1983
Net tons, in thousands	1,447	1,438	76,162	65,763
Capability Utilization Rate	55.9	55.5	70.1	54.2

Composite Prices	This Week	Week Ago	Month Ago	Year Ago
Finished Steel Base* (¢/lb.—eff. 7/1/84)	27.582	27.582	27.582	26.822
Pig Iron** (Net ton=2000 lbs.)	$213.00	$213.00	$213.00	$213.00
Scrap No. 1 hvy.*** (Gross ton=2240 lbs.)	$ 83.17	$ 83.50	$ 85.17	$ 77.83
No. 2 bundles	$ 50.83	$ 51.17	$ 51.50	$ 46.50

Scrap Comparison (Gross Ton)

No. 1 steel, Pittsburgh	$ 88.50	$ 88.50	$ 95.50	$ 82.50
No. 1 steel, Philadelphia	79.50	80.50	81.50	71.50
No. 1 steel, Chicago	81.50	81.50	81.50	79.50
No. 1 bundles, Detroit	75.50	75.50	77.50	81.50
Low Phos., Youngstown	78.50	78.50	80.50	84.50
No. 1 mach'y cast., Pgh	69.50	69.50	71.50	74.50
No. 1 mach'y cast., Phila	98.50	98.50	98.50	95.50
No. 1 mach'y cast., Chi	113.50	113.50	115.50	109.50

*Finished Steel Composite: Weighted index of steel bars, shapes, plates, wire, rails, black pipe, hot and cold rolled sheets and strips.
**Pig Iron Composite: Based on average prices for basic and foundry pig iron at representative producing points within the U.S.
***Steel Scrap Composite: Average of No. 1 hvy. melting steel scrap and No. 2 bundles delivered to consumers at Pittsburgh, Philadelphia and Chicago.

NONFERROUS PRICES

(Effective October 22, 1984) Prices obtained in trade based on representative tonnages per gross ton delivered to consumer unless otherwise stated

Primary Metal Prices

(cents per lb.)	current price	last price	date of change
Aluminum (LME)	45.52	44.57	10/22/84
Copper (C)	61.00-62.00	60.00-62.00	10/19/84
Lead	22.00-26.00	23.00-26.00	10/3/84
Magnesium Ingot	148.00	143.00	5/25/84
Nickel (LME)	216.61	213.88	10/22/84
Titanium Sponge	555.00-585.00	555.00	4/29/82
Zinc	45.00	45.00-48.00	9/21/84

ALUMINUM: Avg. for last week & previous week. COPPER (C) = cathode. LEAD: common grade. MAGNESIUM: 99.8% pig, delivered. NICKEL: Avg. for last week & previous week. Canada. ZINC: high grade.

Antimony, American Laredo, Texas	$2.00
Beryllium-aluminum 5% Be, per lb. contained Be	$230.00
Beryllium-copper, per lb. cont. Be	$140.00
Beryllium 97% powder 200	$178.00
Cadmium, ton lots	$1.55
Calcium, ton lots, crown	$3.58
Chromium, 99.8%	$3.75
Cobalt, 99%, cathode	$12.50
Gold per troy oz.	$338.40
Indium, dollars per troy oz.	$3.30
Iridium, dollars per troy oz.	$450
Magnesium sticks, 10,000 lbs	$1.97
Mercury, per 76-lb. f.o.b. N.Y.	$327-$335
Molybdenum, lb. tech. moly oxides, 20 lb. MO can	$6.85
Nickel electro (PDCR)	$3.29
Palladium, per troy oz.	$140
Platinum, per troy oz.	$330
Rhodium, per troy oz.	$800
Silver ingots, per troy oz.	$7.255
Vanadium	$6.00
Zirconium sponge	$12.00-$17.00

(Per lb. unless otherwise noted)

Straits Tin Price

(U.S. cents per lb, EX-SMELTER, based on daily market in Penang in Malaysian dollars per kilo.)

Oct. 15—549.79 Oct. 18—548.86
Oct. 16—547.54 Oct. 19—549.79
Oct. 17—549.79

Scrap Prices
Brass Mill Scrap

(Cents per lb; over 20,000 lbs. add 1¢ per lb)

	Solids	Turning
Copper	55½	54½
Yellow brass	52¼	51¼
Red brass	53	52¼
Comm. bronze	53⅜	52½
Mang. bronze	55¼	47½
Free cutting rod ends	52	51

Custom Smelters Scrap

(Cents per lb., carload lots, del. refinery)

No. 1 copper wire	52
No. 2 copper wire	43
Light copper	34

Ingot Makers Scrap

(Cents per lb., carload lots, del. refinery)

No. 1 copper wire	48
No. 2 copper wire	39
Light copper	30
No. 1 composition	45
No. 1 comp. turnings	42
Hvy. yellow brass solids	34
Hvy. yellow brass turnings	31
Radiators	37

Aluminum

New mixed clips	32	—33
Old sheet	30	—31
Old cast	30	—31
Clean dry borings	31	—32

Dealers' Scrap

(Dealers' buying price f.o.b. New York in cents per pound)

Aluminum

Segregated clippings	28	—29
Mixed L.C. clips	24	—26
Old sheets and cast	22	—23
Borings and turnings	18	—20
Duraluminum clippings	24	—25

Copper and Brass

No. 1 copper wire	42	—43
No. 2 copper wire	34	—35
Light copper	29	—30
Radiators	31	—32
No. 1 composition	40	—41
No. 1 composition turn'gs	37	—38
Cocks and faucets	27	—28
Clean heavy yellow brass	28	—29
Brass Pipe	29	—30
New soft brass clippings	41	—42

Lead

Heavy soft lead	9	—10
Whole batteries	3	— 4
Type metal	15	—16
Electrotype	13	—14

Nickel

Nickel solids	115	—120
Nickel rod ends	115	—120
Nickel sheets, clips	115	—120
Nickel turnings	40	— 45

Zinc

New zinc clippings	18	— 19
Old diecast zinc	14	— 15

EFFECTIVE OCT. 22, 1984

(Effective October 22, 1984) Prices obtained in trade based on representative tonnages per gross ton delivered to consumer unless otherwise stated. Prices are the opinions of *Iron Age* editors and correspondents, based on contacts with dealers, brokers, generators and users in the industry on the effective date listed above.

Ferrous Scrap Prices

Pittsburgh

No. 1 hvy. melting	$ 88.00 to	$ 89.00
No. 2 hvy. melting	78.00 to	79.00
No. 1 dealer bundles	103.00 to	104.00
No. 1 factory bundles (auto)	99.00 to	100.00
No. 2 bundles	52.00 to	53.00
No. 1 busheling	99.00 to	100.00
Machine shop turn	10.00 to	11.00
Shoveling turnings	51.00 to	52.00
Cast iron borings	49.00 to	50.00
Low phos. punchings plate	107.00 to	108.00
Heavy turnings	78.00 to	79.00
No. 1 RR hvy. melting	96.00 to	99.00
Rails 2 ft. and under	112.00 to	113.00
Scrap rails, random lgth	103.00 to	104.00
RR specialties	105.00 to	106.00
No. 1 machinery cast	69.00 to	70.00
Cupola cast	62.00 to	63.00
Heavy breakable cast	30.00 to	31.00
Stainless		
18-8 bundles and solids	560.00 to	570.00
18-8 turnings	460.00 to	470.00

Chicago

No. 1 hvy. melting	$ 81.00 to	$ 82.00
No. 2 hvy. melting	74.00 to	75.00
No. 1 dealer bundles	97.00 to	98.00
No. 1 factory bundles (auto)	93.00 to	94.00
No. 2 dealer bundles	51.00 to	52.00
No. 1 busheling	97.00 to	98.00
Shredder scrap	96.00 to	97.00
Machine shop turn	44.00 to	45.00
Mixed bor. and turn	46.00 to	47.00
Shoveling turnings	52.00 to	53.00
Cast iron borings	49.00 to	50.00
Low phos. forge crop	117.00 to	118.00
Low phos. punchings plate, ¼ in. and heavier	127.00 to	128.00
Low phos. 2 ft. and under	122.00 to	123.00
No. 1 RR hvy. melting	97.00 to	98.00
Scrap rails, random lgth	99.00 to	100.00
Reroller rails	110.00 to	111.00
Rails, 2 ft. and under	121.00 to	122.00
RR couplers and knuckles	101.00 to	102.00
RR car axles	133.00 to	134.00
No. 1 machinery cast	113.00 to	114.00
Cupola cast	102.00 to	103.00
Stove plate	97.00 to	98.00
Steel car wheels	111.00 to	112.00
Stainless		
18-8 bundles and solids	490.00 to	500.00
18-8 turnings	420.00 to	430.00
430 bundles and solids	120.00 to	125.00
430 turnings	80.00 to	90.00

Philadelphia

No. 1 hvy. melting	$ 78.00 to	$ 81.00
No. 2 hvy. melting	71.00 to	74.00
No. 1 dealer bundles	93.00 to	96.00
No. 2 dealer bundles	47.00 to	50.00
No. 1 busheling	93.00 to	96.00
Shredder scrap	100.00 to	103.00
Machine shop turn	29.00 to	32.00
Mixed bor. and turn	29.00 to	32.00
Shoveling turnings	38.00 to	41.00
Low phos. 5 ft. and under	89.00 to	92.00
Low phos. 2 ft. punchings	114.00 to	117.00
Electric furnace bundles	98.00 to	101.00
RR specialties	96.00 to	99.00
Rails, 2 ft. and under	116.00 to	119.00
Cupola cast	78.00 to	81.00
Heavy breakable cast	57.00 to	60.00
No. 1 machinery cast	97.00 to	100.00

Detroit

Broker buying prices per gross ton on cars:

No. 1 hvy. melting	$ 57.00 to	$ 58.00
No. 2 hvy. melting	56.00 to	57.00
No. 1 dealer bundles	75.00 to	76.00
No. 2 bundles	39.00 to	40.00
No. 1 busheling	74.00 to	75.00
Drop forge flashings	45.00 to	46.00
Machine shop turn	49.00 to	50.00
Mixed borings and turn	26.00 to	27.00
Shoveling turnings	50.00 to	51.00
Cast iron borings	34.00 to	35.00
Heavy breakable cast	40.00 to	41.00
Mixed cupola cast	56.00 to	57.00
Automobile cast	80.00 to	81.00
Stainless		
18-8 bundles and solids	455.00 to	465.00
18-8 turnings	360.00 to	370.00
430 bundles and solids	110.00 to	120.00

Youngstown

No. 1 hvy. melting	$ 64.00 to	$ 67.00
No. 2 hvy. melting	47.00 to	50.00
No. 1 dealer bundles	77.00 to	80.00
No. 2 dealer bundles	35.00 to	38.00
Machine shop turn	13.00 to	16.00
Shoveling turnings	18.00 to	21.00
Low phos. plate	77.00 to	80.00
Electric furnace bundles	74.00 to	77.00
Galvanized bundles	65.00 to	68.00

Cleveland

No. 1 hvy. melting	$ 58.00 to	$ 61.00
No. 2 hvy. melting	37.00 to	40.00
No. 1 dealer bundles	71.00 to	74.00
No. 1 factory bundles	77.00 to	80.00
No. 2 bundles	19.00 to	22.00
No. 1 busheling	76.00 to	79.00
Machine shop turn	8.00 to	11.00
Mixed bor. and turn	8.00 to	11.00
Shoveling turnings	10.00 to	13.00
Cast iron borings	13.00 to	16.00
Cut structural & plates, 2 ft. and under	110.00 to	113.00
Low phos. punchings plate	110.00 to	113.00
Drop forge flashings	42.00 to	45.00
Foundry steel, 2 ft. & under	62.00 to	65.00
No. 1 RR hvy melting	79.00 to	82.00
Rails, 2 ft. and under	115.00 to	118.00
Rails, 18 in. and under	115.00 to	118.00
Steel axle turnings	59.00 to	62.00
Railroad cast	92.00 to	95.00
No. 1 machinery cast	102.00 to	105.00
Cupola cast	58.00 to	61.00
Stove plate	44.00 to	47.00
Stainless		
18-8 bundles	375.00 to	385.00
18-8 turnings	325.00 to	335.00
430 bundles	80.00 to	85.00

Buffalo

Broker buying prices per gross ton on cars:

No. 1 hvy. melting	$ 67.00 to	$ 68.00
No. 2 hvy. melting	56.00 to	57.00
No. 1 busheling	80.00 to	81.00
No. 1 dealer bundles	79.00 to	80.00
No. 2 bundles	39.00 to	40.00
Machine shop turn	14.00 to	15.00
Mixed bor. and turn	13.00 to	14.00
Shoveling turnings	17.00 to	18.00
Cast iron borings	22.00 to	23.00
Low phos. plate	95.00 to	96.00
Structural and plate, 2 ft. and under	98.00 to	99.00
Rails, 2 ft. and under	98.00 to	99.00
Scrap rails, random lgth	77.00 to	78.00
No. 1 machinery cast	81.00 to	82.00
No. 1 cupola cast	61.00 to	62.00

St. Louis

No. 1 hvy. melting	$ 67.00 to	$ 68.00
No. 2 hvy. melting	56.00 to	57.00
Foundry steel, 2 ft.	69.00 to	70.00
No. 1 dealer bundles	67.00 to	68.00
No. 2 bundles	51.00 to	52.00
Machine shop turn	17.00 to	18.00
Shoveling turnings	23.00 to	24.00
Cast iron borings	27.00 to	28.00
No. 1 RR hvy. melting	67.00 to	68.00
Rails, random length	72.00 to	73.00
Rails, 18 in. and under	90.00 to	91.00
RR specialties	87.00 to	88.00
Cupola cast	72.00 to	73.00
Heavy breakable cast	50.00 to	51.00
Stove plate	83.00 to	84.00
Steel car wheels	101.00 to	102.00
Rerolling rails	80.00 to	81.00
Unstripped motor blocks	61.00 to	62.00

Birmingham

No. 1 heavy melting	$ 73.00 to	$ 74.00
No. 2 heavy melting	67.00 to	68.00
No. 1 dealer bundles	75.00 to	76.00
No. 2 bundles	55.00 to	56.00
No. 1 busheling	75.00 to	76.00
Shredder scrap	97.00 to	98.00
Machine shop. turn	24.00 to	25.00
Shoveling turnings	40.00 to	41.00
Cast iron borings	40.00 to	41.00
Electric furnace bundles	69.00 to	70.00
Elec. furnace, 3 ft. & under	73.00 to	74.00
Structural and plate, 2 ft.	103.00 to	104.00
Structural and plate, 4 ft.	93.00 to	94.00
No. 1 RR hvy. melting	93.00 to	94.00
Scrap rails, random lgth	90.00 to	91.00
Rails, 2 ft. and under	108.00 to	110.00
Angles and splice bars	92.00 to	93.00
No. 1 cupola cast	87.00 to	88.00
Unstripped motor blocks	69.00 to	70.00

Cincinnati

Brokers buying prices per gross ton on cars:

No. 1 hvy. melting	$ 57.00 to	$ 58.00
No. 2 hvy. melting	54.00 to	55.00
No. 1 dealer bundles	69.00 to	70.00
No. 2 bundles	30.00 to	31.00
Machine shop turn	5.00 to	6.00
Shoveling turnings	7.00 to	8.00
Cast iron borings	19.00 to	20.00
Low phos. 18 in. and under	88.00 to	89.00
Rails, random length	71.00 to	72.00
Rails, 2 ft. and under	84.00 to	85.00
No. 1 cupola cast	60.00 to	61.00
Heavy breakable cast	28.00 to	29.00
Drop broken cast	78.00 to	79.00

New York

Brokers buying prices per gross ton on cars:

No. 1 hvy. melting	$ 48.00 to	$ 50.00
No. 2 hvy. melting	39.00 to	41.00
No. 2 dealer bundles	23.00 to	27.00
Mixed bor. and turn	11.00 to	13.00
Machine shop turn	6.00 to	7.00
Shoveling turnings	14.00 to	15.00
Clean cast. chem. borings	35.00 to	36.00
No. 1 machinery cast	89.00 to	90.00
Mixed yard cast	50.00 to	51.00
Heavy breakable cast	10.00 to	12.00
Stainless		
18-8 prepared solids	490.00 to	510.00
18-8 turnings	390.00 to	410.00
430 prepared solids	90.00 to	110.00
410 solids	80.00 to	90.00

Boston

Brokers buying prices per gross ton on cars:

No. 1 hvy. melting	$ 68.00 to	$ 70.00
No. 2 hvy. melting	58.00 to	60.00
No. 1 dealer bundles	68.00 to	70.00
No. 2 bundles	41.00 to	43.00
No. 1 busheling	75.00 to	77.00
Shredder scrap	74.00 to	76.00
Machine shop turn	14.00 to	16.00
Shoveling turnings	22.00 to	24.00
No. 1 machinery cast	85.00 to	90.00
Mixed cupola cast	54.00 to	56.00
Heavy breakable cast	10.00 to	12.00

San Francisco

No. 1 hvy. melting	$ 47.00 to	$ 49.00
No. 2 hvy. melting	41.00 to	43.00
No. 1 dealer bundles	37.00 to	39.00
No. 2 dealer bundles	19.00 to	21.00
Machine shop turn	6.00 to	8.00
Cast iron borings	6.00 to	8.00
No. 1 cupola cast	81.00 to	83.00

Los Angeles

No. 1 hvy. melting	$ 48.00 to	$ 50.00
No. 2 hvy. melting	41.00 to	43.00
No. 1 dealer bundles	38.00 to	40.00
No. 2 dealer bundles	19.00 to	21.00
Machine shop turn	10.00 to	12.00
Shoveling turnings	8.00 to	10.00
Cast iron borings	6.00 to	8.00
Elec. furnace, 1 ft. and under (foundry)	77.00 to	79.00
No. 1 cupola cast	75.00 to	77.00

Seattle

No. 1 hvy. melting	$ 70.00 to	$ 72.00
No. 2 hvy. melting	59.00 to	61.00
No. 2 bundles	41.00 to	43.00
No. 1 cupola cast	94.00 to	95.00
Mixed yard cast	84.00 to	86.00

Hamilton, Ont.

Brokers buying price per net ton on cars:

No. 1 heavy melting	$ 91.00
No. 2 heavy melting cut 2 ft. and under	87.00
No. 1 dealer bundles	92.00
No. 2 bundles	53.00
Mixed steel scrap	82.00
Bush. new fact. prep'd.	93.00
Bush. new fact. unprp'd.	83.00
Machine shop turn	41.00
Short steel turn	43.00
Mixed bor. and turn	30.00
Cast scrap	79.00

Houston

Brokers buying prices per gross ton on cars:

No. 1 hvy. melting	$ 73.00 to	$ 74.00
No. 2 hvy. melting	60.00 to	61.00
No. 2 bundles	45.00 to	46.00
Machine shop turn	16.00 to	17.00
Crushed turnings	34.00 to	35.00
Shredder scrap	76.00 to	77.00
Cut structural plate, 2 ft. and under	102.00 to	104.00
Cut structural plate, 5 ft. and under	86.00 to	88.00
Unstripped motor blocks	60.00 to	61.00
Cupola cast	80.00 to	81.00

PRODUCER KEY
With Principal Offices

A4 American Cladmetals Co., Carnegie, Pa.
A7 Armco Inc., Middletown, Ohio
A8 Atlantic Steel Co., Atlanta, Ga.
A11 Atlantic Wire Co., Branford, Conn.

B1 Baron Drawn Steel Corp., Toledo, Ohio
B3 Bethlehem Steel Corp., Bethlehem, Pa.
B4 Blair Strip Steel Co., New Castle, Pa.
B5 Bliss & Laughlin Steel Co., Harvey, Ill.

C1 Calstrip Corp., Los Angeles
C8 CF&I Steel Corp., Pueblo, Colo.
C10 Copperweld Steel Co., Warren, Ohio
C11 Crucible Divisions, Colt Industries, Pittsburgh, Pa.
C15 G. O. Carlson, Inc., Thorndale, Pa.
C16 Connors Steel Co., Birmingham, Ala.
C20 Calumet Steel Div., Chicago Heights, Ill.
C21 Cumberland Steel Co., Cumberland, Md.

D1 Detroit Strip Div., Cyclops Corp.
D2 Driver Wilber B., Co., Newark, N. J.
D3 Driver Harris Co., Harrison, N. J.

E3 Enamel Products & Plating Co., McKeesport, Pa.
E4 Elliot Bros. Steel Co., New Castle, Pa.

F1 Firth Sterling, Inc., McKeesport, Pa.

G2 Granite City Steel Co., Granite City, Ill.
G3 Great Lakes Steel Division, National Steel Corp., Ecorse, Mich.
G4 Greer Steel Co., Dover, O.
G5 Green River Steel Corp., Owensboro, Ky.
G6 Gibraltar Steel Corp., Buffalo, N. Y.
G7 Georgetown Steel Corp., Georgetown, S. C.
G8 Guterl Special Steel Corp.

H1 Hercules Drawn Steel Corp., Livonia, Mich.

I2 Ingersoll Steel Div., New Castle, Ind.
I3 Inland Steel Co., Chicago, Ill.
I4 Interlake Steel Corp., Chicago

J2 Jessop Steel Corp., Washington, Pa.
J3 Jones & Laughlin Steel Corp., Pittsburgh
J4 Joslyn Mfg. & Supply Co., Chicago
J5 Judson Steel Corp., Emeryville, Calif.

K2 Keystone Consolidated Industries, Inc.
K3 Kentucky Electric Steel Co., Ashland, Kentucky
K5 Kemco Div., Foote Mineral Co., Kekuk, Iowa

L2 La Salle Steel Co., Chicago
L3 Lone Star Steel Co., Dallas
L4 Lukens Steel Co., Coatesville, Pa.
L5 Litho-Strip Corp., Chicago

M2 McLouth Steel Products Corp.
M4 Mid States Steel & Wire Co., Crawfordsville, Ind.
M8 Mill Strip Products Div., National Steel Service Center, National Steel Corp.
M9 Moltrup Steel Products Co., Beaver Falls, Pa.
M11 Midwest Steel Div., National Steel Corp., Portage, Ind.

N1 Northeast Precision Steel Co., Boston, Mass.
N4 Northwestern Steel & Wire Co., Sterling, Ill.
N6 Northwest Steel Rolling Mills, Seattle, Wash.
N9 Nelsen Steel & Wire Co., Chicago, Ill.
N10 North Star Steel Co., Saint Paul, Minnesota

O2 Oregon Steel Mills, Portland, Ore.

P2 Phoenix Steel Corp., Claymont, Del.
P9 Pacific States Steel Co., Niles, Cal.
P14 Pacific Tube Co., Los Angeles
P15 Philadelphia Steel and Wire Corp., Phila.

R3 Republic Steel Corp., Cleveland
R4 Ramco Steel Co., Buffalo, N. Y.
R5 Robin Steel Corp., Inc., North Tonawanda, N. Y.
R6 Rodney Metals, Inc., New Bedford, Mass.
R7 Rome Strip Steel Co., Rome, N. Y.

S1 Sharon Steel Corp., Sharon, Pa.
S7 Stanley Works, New Britain, Conn.
S8 Superior Drawn Steel Co., Monaca, Pa.
S10 Seneca Steel Service, Buffalo, N. Y.
S16 Southern Precision Steel Co., Gulfport, Miss.

T4 Thomas Steel Strip Co., Warren, O.
T5 Timken Company, Steel Division, Canton, O.
T7 Texas Steel Co., Fort Worth, Tex.
T9 Triumph Electro Corp., Chicago, Ill.
T10 Tennessee Forging Steel Corp., Harriman, Tenn.
T11 Teledyne Columbia-Summerill, Carnegie, Pa.

U1 United States Steel Corp., Pittsburgh, Pa.

W3 Weirton Steel Corp., Weirton, West Va.
W5 Wheeling-Pittsburgh Steel Corp.
W7 Wilson Steel & Wire Co., Chicago
W10 Wyckoff Steel Div., Ampco-Pittsburgh Corp., Pittsburgh, Pa.
W14 Whittaker Steel Strip Div., Detroit, Mich.

STEEL SERVICE CENTER PRICES

Price, Dollars per 100 lb

Prices are based on list prices reported to *Iron Age* by a number of metal service centers deemed representative by *Iron Age* and then weighted based in part on the reports received each month. Prices are not intended to reflect the actual transaction prices obtained by any individual metal service center.

Cities*	Sheets			Strip	Plates	Shapes	Bars		Alloy Bars			
City Delivery Charge*	Hot-Rolled (10 gage)	Cold-Rolled (20 gage)	Galvanized (16 gage)	Hot-Rolled Strip	Plates	Standard Structurals	Hot-Rolled (merchant)	Cold Finished	Hot-Rolled 8620 As Rolled	Hot-Rolled 4140 Annealed	Cold-Drawn 8620 As Rolled	Cold-Drawn 4140 Annealed
Atlanta	29.65	33.55	34.48	31.63	27.02	23.28	19.55	31.25	34.34	50.60	69.58	73.19
Baltimore	26.90	30.72	37.59	39.82	34.75	28.80	22.60	38.65	57.45	64.70	71.71	75.11
Birmingham	26.60	32.82	34.59	31.64	26.64	23.01	19.99	30.91	49.31	58.90	68.10	74.43
Boston	34.94	40.19	45.64	47.54	35.34	30.06	23.59	40.29	47.92	51.02	58.48	63.50
Buffalo	31.10	35.68	41.89	40.15	32.59	27.12	19.86	37.75	44.15	47.85	53.92	59.84
Chicago	29.26	34.62	37.84	32.74	25.10	22.00	17.70	31.53	38.02	41.09	46.52	52.75
Cincinnati	28.91	34.58	37.16	30.85	24.84	20.75	17.96	32.96	37.16	42.54	46.63	52.44
Cleveland	28.48	34.22	37.48	36.74	26.92	26.13	18.81	38.35	42.14	45.56	49.98	55.88
Denver	33.62	38.88	40.88	36.36	34.45	28.66	21.82	44.31	52.10	60.06	67.39	75.21
Detroit	29.21	36.65	37.87	31.39	26.63	23.86	16.96	32.71	37.18	42.51	46.81	53.49
Houston	27.67	30.98	37.71	39.21	26.73	27.73	24.22	40.15	48.97	55.05	61.50	68.89
Kansas City	31.68	36.89	40.00	36.84	28.03	30.65	20.13	33.82	42.07	47.84	53.21	60.30
Los Angeles	27.01	31.33	37.84	35.32	29.83	33.12	26.52	41.33	53.89	63.84	65.43	72.14
Memphis	26.37	32.51	35.34	33.57	27.75	26.63	21.40	33.87	36.78	49.96	59.80	69.44
Milwaukee	29.35	34.89	37.85	33.06	26.02	24.18	17.58	30.89	36.58	41.85	45.86	52.80
New York	32.47	38.99	42.55	43.38	33.96	27.21	21.06	40.88	45.78	49.07	61.12	65.86
Philadelphia	30.41	36.99	41.23	43.50	31.05	28.11	20.85	39.24	46.18	50.25	61.22	65.42
Pittsburgh	35.27	40.97	45.23	43.45	37.60	30.44	21.29	29.80	41.40	47.58	53.03	60.02
Portland	28.96	32.06	38.73	36.93	32.88	34.78	27.87	44.85	49.78	57.74	70.44	....
San Francisco	26.94	31.95	38.60	35.58	28.61	31.19	25.78	39.72	52.11	60.36	67.30	73.42
Seattle	23.61	30.12	36.65	32.95	22.02	27.32	25.91	39.14	53.03	61.70	69.75	74.93
Spokane	21.21	30.42	35.65	38.02	35.00	33.77	21.97	43.01	43.20	47.52	....	58.32
St. Louis	29.11	34.80	37.31	34.59	26.19	22.90	18.40	33.87	38.12	43.51	48.85	53.89
St. Paul	28.87	33.61	36.99	38.36	26.91	23.73	17.70	33.96	37.52	42.72	47.09	53.31

Base Quantities. All HR products may be combined for quantity. Hot-rolled sheet, 10 ga x 36 x 96—120; Cold-rolled sheet, 20 ga x 36 x 120; Galv. sheet—16 ga x 36—120; Hot-rolled strip—⅛" x 1"; Plate ¼" x 84/; Shapes—I-Beams 6 x 12.5; Hot-rolled bar—Rounds ¾-2"; Cold finished bar—C 1018—1" rounds; Alloy bar—Hot-rolled 8620—1½" round; Cold drawn—1" round; Hot-rolled 4140—1½" round; Cold drawn—1" round. Check local supplier for additions or deductions from base.

*Prices at all points include metropolitan delivery charges.

Codes identify Producers listed in the Key on page 67. (Prices quoted are mill base prices in cents per pound unless otherwise noted and do not reflect extras or surcharges.) N.A. – Not available.

Billets, Blooms, Slabs

(Dollars per net ton)

Carbon Rerolling, Midwest	
W5	$366.00
N4	$366.00
West	
C6	$346.00
Carbon Forging, East	
B3(2), C10, U1	$473.00
R3	$453.00
Midwest	
R3, W5	$453.00
S1, U1, I3	$473.00
C10	$473.00
K2	$453.00
West	
B3(2)	$463.00
C6	$453.00
Alloy, East	
R3	$492.00
B3, U1, C10	$512.00
Midwest	
W5	$492.00
U1, C10, I3	$512.00
R3	$492.00
S1	$512.00
West	
B3	$502.00
C6	$469.00

Piling Sheet Steel

(cents per lb)

Midwest	
U1	26.45

Structurals

Carbon, East	
B3	22.90
U1, J3	23.90
Midwest	
C20	22.90
W8	22.90
I3, T10, U1, N4	23.90
West	
C6	25.10
B3(2)	21.65
South	
C16, U1	23.90
T10	22.90
A8	Cmp*
High-Strength, Low Alloy, East	
B3	22.90
U1, J3	23.90
Midwest	
N4	23.90
W8	24.15
U1	23.90
I3	23.90
West	
B3	21.65
South	
U1, C16	23.90
Wide Flange, Carbon, East	
B3	22.90
U1, J3	23.90
Midwest	
U1	23.90
N4	23.90
I3	23.90
West	
C6	24.15

Strip

Hot-Rolled, Carbon, Cut ll Edge—all widths, East	
U1, B3	23.75
J3	22.05
Midwest	
D1	22.05
I4	22.85
J3, D1, W3	22.05
G2, G3	23.45
N4	22.55
W5, S1, A7	23.75
U1, B3, I3	23.75
M2, R3	22.05
West	
B3	26.55
South	
R3	22.05
Cold-Rolled, Carbon Max. 25%, East	
E4	29.75
S10	29.60
P15	24.80
B4	36.60
G6	36.175
Midwest	
I4	36.30
W14	32.80
J4	34.05
S1	37.05
High-Strength, Hot-Rolled, Low Alloy, Cut Edge & Mill Edge—all widths, (plus extras)*	
Midwest	
M2, R3, W3, J3, I3	22.05
G2, G3	23.45
S1	23.75
A7	25.35
South	
R3	22.05
High-Strength, Cold-Rolled, Low Alloy, Mill Edge	
Midwest	
S1	37.05
Alloy, Hot-Rolled, Midwest (plus extras)*	
S1	26.10
I4	25.20
Alloy, Cold-Rolled, East	
C11, E4, M8	43.35
B4	47.25
P15	32.10
Midwest	
I4	44.30
S1	44.80

Sheets

Hot-Rolled, Carbon (18 Ga & Hvyr), East	
B3	23.75
J3	22.05
U1	23.75
Midwest	
M2, R3, W3	22.05
D1, J3	22.05
G2, G3	23.45
I4	22.45
U1, W5, S1, B3, I3, A7	23.75
West	
U1	24.25
South	
R3	22.05
Cold-Rolled, East, Class I	
B3(2)	28.15
J3	26.15
U1	28.15
Midwest	
R3, M2, W3	26.15
G2, G3, M11	27.85
I4	22.00
J3	26.15
D1	26.15
U1, W5, S1, B3, I3, A7	28.15
West	
U1	28.65
South	
R3	24.65
Galvanized (hot-dipped), East	
B3(2)	30.30
U1	30.30
Midwest	
J3, D1, W3	28.00
R3, Y1	28.00
G2, M11	30.00
U1, W5, S1, I3, A7	30.30
West	
U1	30.80
South	
R3	28.00
Enameling, Midwest	
U1, S1, I3, A7	29.65
J3	27.65
Long-Terne, Midwest	
W5, A7	31.65
U1	31.65
R3	29.35

Wire Rod

East	
B3(2)	22.26
Midwest	
N4, K2	22.35
U1	24.10
A7	22.00
West	
C6	21.45
South	
G7	22.35

Tinplate

Electrolytic Tinplate
Single Reduced (70 lb)

East	per base box
J3	$26.29
U1	27.74
B3	27.54
Midwest	
U1	$27.74
J3	26.29
M11	27.24
W3	26.29
W5	27.74
West	
U1	$28.24
South	
U1	$27.74

Double Reduced (55 lb)**

Midwest	
M11	$21.87
J3	21.49
U1	22.37
W3	21.49
W5	22.37
West	
U1	$22.87
South	
U1	$22.37

Black Plate
Single Reduced (75 lb)*

East	
B3	$24.31
Midwest	
J3, W5	$24.01
I3, W5	24.57
W3	24.01
U1, M11	25.26
West	
U1	$25.26

Double Reduced (55 lb)

East	
B3	$20.49
Midwest	
M11	$19.70
W5	19.70
J3	18.93
W3	18.93
W5	18.93
U1	19.70
West	
U1	$19.70
South	
U1	$19.70

*70 lb—base weight extra 45¢
**50 lb—base weight extra $1.40

Bars

Carbon Steel, Hot-Rolled
(Special quality)

East	
R3, K3	25.80
R5	25.80
J3	25.80
U1, C10, B3(3)	27.05
Midwest	
I4	23.95
U1, I3	27.05
R8, T10, C20, N4	25.80
K2	25.80
I3	22.00*
A7	20.25
West	
B3	25.80
C6	24.45
South	
A8	20.65
C16	25.80
Cold-Finished Carbon, East	
A11	22.15
R3	33.75
C21	21.15
J3(4), L2	31.00
M8, W10, T11, S8	31.00
N1	24.475
R4	33.25
B4	33.25
C10	31.00
Midwest	
W10, R3, M9	33.25
J3	31.00
B1	33.45
L2	30.75
N9	31.00
W14	22.00
B6	34.75
West	
R3	37.15
South	
J3	34.00
C16	24.40
J3	31.90
Alloy, Hot-Rolled, East	
R5, K3	27.95
R3, J3	27.95
U1, B3(2), C10	29.20
Midwest	
R3	27.95
I3, C10, U1	29.20
I4	26.10
I3	23.50*
A7	20.25
West	
B3	27.95
C6	25.60
South	
A8	22.00
Alloy, Cold Drawn, East	
L2	35.20
R3, N1	37.90
R4	37.10
A11	30.50
J3, W10, L2	34.85
T11, S8	34.85
C10	34.85
Midwest	
R3	37.35
J3, W10, C10	34.85
B1	37.30
N9	34.85
L2	34.65
B5	38.60
M9	37.10
West	
R3	40.75
South	
J3	35.85
C16	28.00

Plates

Carbon Steel, East	
B3	23.25
L4, U1	25.75
P2	25.75
J3	26.75
Midwest	
B3	23.25
I3	25.75
J3, A7	22.80
U1, I4, S1	25.75
R3	26.75
West	
C6	24.25
U1, B3	25.75
O2	23.00
South	
R3	25.75
U1	25.75
Alloy, East	
B3	31.05
U1, L4	33.55
P2	33.55
J3	34.55
Midwest	
B3	31.05
G2, G3	33.55
I4, U1	33.55
West	
B3	33.55
O2	31.00
South	
U1	33.55

Wire

Carbon Steel Wire, East	
B3	27.10
A11	22.15
Midwest	
R3	24.60
N4, W7	27.40
K2	24.20
South	
A8	22.85
West	
C6	24.95